

## REMARKS

### **I. Status of the Application**

As an initial matter, Applicants note that by filing this Response and the accompanying Request for Continued Examination, this application is been withdrawn from Appeal.

In this Response, Applicants maintain their previously presented arguments (see Sections V and VI, below) and additionally address certain characterizations of the prior art and certain arguments regarding combining the prior art that have been presented in an Office Action dated June 14, 2010 in a co-pending application, Serial No. 10/621,999 (also being examined by Ex. Olsen) (see Section IV, below). These characterizations of the prior art and arguments regarding combining the prior art presented in the co-pending application are relevant to this application and were first available to the Applicants after the April 5, 2010 Notice of Panel Decision in the present application. In the interest of developing a full and complete record, Applicants have elected to address these issues which have heretofore not been presented by the Examiner nor addressed by Applicants in this present prosecution.

A courtesy copy of the June 14, 2010 Office Action for Serial No. 10/621,999 is provided with this Response.

### **II. Status of the Claims**

Claims 1 – 67, 70 – 74 and 76 – 133 are pending in the application. Claims 1 – 13, 29 – 34, 52 – 67 and 70 – 132 stand rejected. Claim 133 has been added.

Claims 1 – 67, 70 – 74 and 76 – 132 stand rejected as requiring a supplemental reissue oath/declaration.

Claims 1, 2, 9 – 12, 29 – 34, 52, 54 and 61 – 64 stand rejected on the ground of *res judicata*.

Applicants acknowledge the Examiner's allowance of claims 35 – 51 and the indication that claims 6-8, 14 – 28 58-60, 83-85, 91-105 and 118-120 would be allowable if rewritten in independent form, pending receipt of an appropriate supplemental reissue declaration.

### III. Summary of Applicants' Main Points

Every Section 103 rejection in the present application relies, at least, on the combination of Dempsey with Uchida, Vanderborgh and/or Grot. Dempsey discloses a gas sensor having hydrophobic electrodes on either side of a Nafion<sup>®</sup> membrane, wherein the membrane is hydrated with liquid water. The claims require electrodes having a "proton-electron mixed conductive material having 10-50 wt% of a proton conductor material and 50-90 wt% of a first and second electrical conductor material." The Examiner asserts that each of Uchida, Vanderborgh and Grot disclose this required electrode composition, and further that it is proper to replace Dempsey's hydrophobic electrodes with the electrodes disclosed in Uchida, Vanderborgh and/or Grot.

First, Uchida and Vanderborgh fail to disclose the claimed composition of the "proton-electron mixed conductive material."

Second, it is not proper to combine Dempsey with Grot (and/or *arguendo* with Uchida or Vanderborgh), as the combination would render Dempsey inoperative. The relied-upon electrodes of Grot are hydrophilic. Dempsey expressly discloses hydrophobic electrodes and, in fact, Dempsey's electrodes must be hydrophobic to keep the adjacent liquid water from flooding them. Flooded electrodes would render Dempsey's sensor inoperable. Thus, replacing Dempsey's hydrophobic electrodes with the hydrophilic electrodes of Grot would allow the liquid water to flood the electrodes, thereby rendering Dempsey inoperative.

Third, none of the cited references teach or suggest that a hydrophilic electrode, such as disclosed by Grot, may be converted to a hydrophobic electrode by the addition of a coating or other water repellant treatment (or by any other means) such that the coated/treated hydrophilic electrode would not flood when immersed in liquid water.

Fourth, not every element of the claims is disclosed by Dempsey in combination with Grot. Specifically, the claims require exposing a surface of the counter electrode to water vapor. In contrast, Dempsey discloses exposing the counter electrode to liquid water. Liquid water and water vapor are not equivalent (see discussion of Schroeder's paradox, below), hence the claims' express recitation of "water vapor," not just of "water." A person of ordinary skill in the art would recognize that Dempsey teaches away from the use of water vapor, because Dempsey teaches the use of liquid water to be critical to the operation of its device.

Certain of the claims are directed to sensors having only two electrodes. The Examiner asserts that either Tomantschger (US 5,302,274) or Nagata (each in combination with Dempsey with Uchida, Vanderborgh and/or Grot) render these "two electrode" claims unpatentable. Dempsey discloses a gas sensor having three electrodes—a sensing electrode and a counter electrode plus a reference electrode. Dempsey's reference electrode forms the linchpin for Dempsey's potentiostated circuitry, which is used to maintain the sensing electrode above a certain potential and thereby to ensure temperature invariant current characteristics at a zero-air condition (see title). Thus, Dempsey teaches away from a two electrode device, and certainly, cannot fairly be modified by eliminating its reference electrode.

Each of Tomantschger and Nagata disclose that three electrode sensors can be converted to two electrode sensors by eliminating the reference electrode. However, eliminating Dempsey's reference electrode to convert Dempsey's three electrode sensor to a two electrode sensor would destroy Dempsey's potentiostated circuitry. If one were to eliminate the reference electrode from Dempsey, as the Examiner urges: (1) Dempsey's principle of operation would be changed; and (2) Dempsey's gas sensor would be rendered unsatisfactory for its intended purpose. Both of these are impermissible.

Finally, the Examiner's invocation of *res judicata* to reject certain claims that were previously before the Board of Appeals is improper. Rather, the new record,

including new evidence, placed before the Examiner in this prosecution, present new issues that must be substantively addressed by the Examiner.

**IV. Discussion of Examiner Olsen's Remarks Regarding the Prior Art and its Combinations Made in the Response to Arguments Section of the June 14, 2010 Office Action in Co-pending Application Serial No. 10/621,999**

In the June 14, 2010 Office Action in the co-pending application, the Examiner raised certain points regarding the prior art (Dempsey, Uchida, Vanderborgh, Grot, Surampudi, Cisar, LaConti, Tomantschger, Nagata, etc.) and certain combinations thereof. As the Examiner or the Board of Appeals may consider these points to be relevant to the instant application, Applicants address these points in paragraphs (a) through (i) below.

As a preliminary matter, Applicants note that in the Response to Arguments section of the June 14, 2010 Office Action, the Examiner several times refers to Applicants' own disclosure either in the instant application or in the co-pending application for his rationale for combining references or for what the cited references teach (see e.g., items 62, 67, 69). Applicants' own disclosures, either in the instant application or in the co-pending application (both filed July 17, 2003), are not "prior art." Thus, Applicants respectfully submit that it is improper for the Examiner to rely in the teaching of these applications to make or bolster his arguments as to the teachings of the prior art references or the rationale for combining references. Furthermore, Applicants submit that their teachings are not inconsistent with their arguments as to what the prior art references taught to persons of ordinary skill in the art at the time the invention was made or whether a person of ordinary skill in the art at the time the invention was made would have a rationale to combine the prior art teachings.

- (a) **Uchida fails to disclose "a proton-electron mixed conductive material having 10-50 wt% of a proton conductor material and 50-90 wt% of a first and a second electrical conductor material."**

The Examiner argues in the June 14, 2010 Office Action, paragraph 63, that "a proton-electron mixed conductive material" doesn't require that the material be mixed,

only that the material is “a material possessing both proton and electron conduction.” The Examiner further asserts that this recitation reads on Uchida’s use of a separate coating step to form a separate layer of Nafion® (a proton conductor) over an electron conductive catalyst layer, because (1) the claims don’t require that the material is mixed, and thus, separate layers are encompassed by the claims; or alternatively, (2) the Nafion® coating is not a separate layer because the catalyst layer is porous and the Nafion® coating is integrated into the electron conductive material.

As to point (1), the claims do require that the proton-electron mixed conductive material is a single mixed material, not layers. “During examination, ‘claims . . . are to be given their broadest reasonable interpretation consistent with the specification, and . . . claim language should be read in light of the specification as it would be interpreted by one of ordinary skill in the art.’” (See *Ex parte Jenkins*, BPAI, Appeal 2009005028 (September 2009)). In this case, the specification explicitly discloses that the proton-electron mixed conductive material has the proton conductor material and the electron conductor material mixed together. For example, the specification discloses that the protonic conductor and the electronic conductors are mixed together as a wet electrode mixture which is then dispensed onto the surface of the membrane and dried (see col. 15, line 26 to col. 16, line 17). Thus, the specification discloses that the proton-electron mixed conductive material is formed as a “mixture,” *i.e.*, a single mixed material, not layers of unmixed materials. Further, FIG. 7 of the specification discloses a layer of material with electronic conductive phase material 82 and a protonic conductive phase material 84 dispersed and mixed throughout the layer, *i.e.*, FIG. 7 shows a mixed proton-electron conductive material as a single mixed material (see FIG. 7; col. 12, lines 63-64; and col. 13, lines 29-30).

As to point (2), applying a Nafion® coating onto a previously formed catalyst layer does not form a “proton-electron mixed conductive material,” even if the catalyst layer is porous. As an analogy, applying marmalade to an English muffin does not create a new material no matter that the marmalade gets into the nooks and crannies of the muffin—it’s still marmalade on a muffin. And in fact, Uchida recognizes that applying a

Nafion<sup>®</sup> coating onto a catalyst layer (the comparative example, cell X, disclosed at col. 7, line 55 to col. 8, line 7) is different than (and inferior to) forming a mixed Nafion<sup>®</sup>/catalyst material (Uchida's inventive examples, cells A, B, C, D, E, F, and A'). Although the Examiner refers to Figs. 2 and 3 of Uchida, these illustrate Uchida's invention examples, not the comparative example of the Nafion<sup>®</sup>-coated cell X.

Thus, Applicants maintain, as further discussed below, that Uchida does not disclose the claimed electrode composition and is, thus, not relevant.

- (b) **Vanderborgh fails to disclose “a proton-electron mixed conductive material having 10-50 wt% of a proton conductor material and 50-90 wt% of a first and a second electrical conductor material.”**

The Examiner argues in the June 14, 2010 Office Action, paragraph 64, that “if a mixture of two different materials can be construed as being a singular “material” *as would be necessary for interpreting the present claims in view of the specification*, it is unclear why an electrode constructed of three *separate* layers cannot also be construed as being [the claimed proton-electron mixed conductive material]” (italics added).

The Examiner appears to recognize that construing the claim language in light of the specification (see the italicized portion of the above quote) requires that the mixture of proton conductor materials and electron conductor materials be construed as a single material. This is the point that Applicants were making in section (a) above. The mixture of different component materials results in a single mixed material, much like flour, milk, eggs, when mixed together, become pancake batter.

The Examiner also appears to recognize that Vanderborgh discloses three *separate* layers. These separate layers are not mixed together to form a mixed material, rather, they are layered upon each other and retain their separate material identity, much like a layer of old white paint when covered with a new layer of red paint, does not become a layer of pink paint, but retains the separate identities of the individual white and red paint layers.

Thus, Applicants maintain, as further discussed below, that Vanderborgh does not disclose the claimed electrode composition and is, thus, not relevant.

**(c) Grot discloses an electrode composition that is liquid water permeable.**

The Examiner argues in the June 14, 2010 Office Action, paragraph 60, that “Grot teaches that the binder for the electrode can contain materials such as hydrophobic polytetrafluoroethylene (i.e. Teflon®) and also suggests the use of surfactants ... presumably also to control the wetting ability of the electrode. Hence, [Grot’s] teachings already suggest that the hydrophobic character of the electrodes can still be controlled even though the electrodes contain Nafion®, and [Grot’s] teachings suggest the use of further hydrophobic treatment.” Applicants disagree.

First, surfactants facilitate wetting or hydrophilic behavior. Additionally, Grot’s teachings as to the “use of surfactants” is for when the binders and other ingredients are being added to the suspension media of the ink (cols. 5 and 6) in order to improve the dispersibility [of these components within the ink suspension media] (col. 5, lines 65-68). Thus, contrary to the Examiner’s presumption, Grot’s teachings of the “use of surfactants” is not a teaching as to “controlling the wetting ability of the electrode” and is not a teaching “suggest[ing] the use of further hydrophobic treatment.”

Second, Grot’s teaching that other suitable binders include Teflon® or other binders (col. 5, lines 63-65) is devoid of any mention of Teflon®’s hydrophobic properties or of any mention of controlling the wetting ability of the electrode. In fact, Grot fails to link the use of Teflon® as a binder to any teaching of “controlling the hydrophobic character of the electrode.” Grot just does not teach to a hydrophobic electrode.

Even further, Grot’s example electrode ink composition (col. 14, lines 15-27) includes no Teflon® (or any other binder other than Nafion®). Yet, indeed, this example electrode ink composition of Grot’s is the very disclosure relied upon by the Examiner for allegedly disclosing the claimed electrode composition. Nor is there any further discussion or suggestion in Grot, with respect to this electrode ink composition, of

“controlling the hydrophobic character of the electrode” or of “the use of further hydrophobic treatment.” Rather, as briefly discussed below, Grot explicitly states that the “the membrane and electrode structure is also useful in electrolytic cells” (col. 13, lines 35-36). As electrolytic cells involve the electrolysis of aqueous solution, it is preferable that these electrodes be liquid permeable. In other words, rather than seeking to make its electrodes hydrophobic, Grot embraces the liquid permeability of its electrodes.

**(d) Surampudi evidences that persons of ordinary skill in the art would have known that the addition of Nafion® to an electrode composition would make the electrode more liquid permeable.**

The Examiner argues in the June 14, 2010 Office Action, paragraphs 59 and 60, that “it is unclear how Surampudi is relevant to the present issues when Surampudi didn’t disclose the use of any wetting [sic, *anti*-wetting] treatments and when none of the secondary teachings [Grot et al.] considered the switch from Teflon® to Nafion® to be detrimental to the electrode function.”

First, in the context of the *individual* prior art references, there is no reason for any of the references to consider the addition of Nafion® to be detrimental. Indeed, Grot discloses that the use of Nafion® is preferred, among other reasons, because the electrode ink with Nafion® as a binder readily adheres to the membrane (see col. 4, lines 15-29). However, Grot says nothing of operating its electrode as a “gas-diffusion electrode” when the electrode is immersed in liquid water. It is under these conditions (which, indeed, are the disclosed operating conditions of the Dempsey device), that Applicants submit that the use of Nafion® as disclosed by Grot is detrimental.

Applicants rely on Surampudi as evidence that a person of ordinary skill in the art, at the time of the invention, would have recognized that Grot’s use of Nafion® as the electrode binder would have produced an electrode that allows liquid to penetrate its pores, and that such a liquid permeable electrode would be flooded and rendered inoperable under the Dempsey operating conditions (i.e., operation of Grot’s electrode as a “gas-diffusion electrode” when immersed in liquid water would be impossible).



Surampudi discloses that the structure and properties of an electrode for use in liquid feed type fuel cells are quite different from the structure and properties of an electrode for use in gas/vapor feed fuel cells (col. 2, lines 34-42). This disclosure of Surampudi, at the very least, teaches that fuel cell electrodes are not willy-nilly interchangeable—always, the operating conditions must be considered when selecting a suitable electrode composition.

Surampudi discloses that an electrode having a Teflon® binder will not flood, but an electrode having a Nafion® binder will be liquid permeable. For example, Surampudi discloses that prior art electrodes formed as carbon-supported alloy powder combined with Teflon® binder yield gas-diffusion electrodes (col. 2, lines 25-27). Further, Surampudi discloses that these prior art gas-diffusion type electrodes cannot be effectively used in liquid feed type fuel cells as the electrode is not adequately wetted by the liquid fuel (col. 2, lines 34-37). Surampudi then discloses that “the electrode structures for use in a liquid feed fuel cell should be very porous and the liquid fuel solution should wet all pores” (col. 2, lines 37-39). Finally, Surampudi discloses that the addition of Nafion® to the electrode promotes wetting of the electrode pores, thereby providing an electrode structure suitable for liquid feed type fuel cells (col. 12, lines 41 – col. 14, line 13).

- (e) **None of the cited prior art references teach or suggest that “further hydrophobic treatment” would rendered a liquid permeable electrode impermeable when immersed in liquid water.**

The Examiner has indicated in the June 14, 2010 Office Action, paragraphs 59 and 60, that the secondary references (Grot et al.) suggest the use of further hydrophobic treatments (*i.e.*, anti-wetting treatments). The Examiner further indicates that it is unclear how Surampudi is relevant to the present issues when Surampudi didn't disclose the use of any wetting [*sic*, *anti-wetting*] treatments. Thus, Applicants assume that the Examiner is suggesting that Grot's liquid permeable electrode could be made non-liquid permeable (even when surrounded by liquid water as taught by Dempsey), while still maintaining its operability, by the addition of some further hydrophobic treatments.

First, as discussed above, Grot fails to disclose or suggest further hydrophobic treatments.

Second, there is no teaching or suggestion in any of the references that a liquid permeable electrode, such as taught by Grot, could be made non-liquid permeable by the addition of some further hydrophobic treatments such that when surrounded by liquid water, as taught by Dempsey, it would still maintain its operability as a gas-diffusion electrode.

The Examiner asserts that Uchida teaches the use of a water repelling treatment. However, Applicants note that Uchida discloses the use of a water repelling treatment only in the context of gas-diffusion type electrodes that operate in a gas environment. In this context of a gas operating environment, Uchida discloses the addition of a fluoropolymer (e.g., Teflon<sup>®</sup>) to enhance the ability of gas feeding to the reaction site (col. 2, line 66 to col. 3, line 5). Uchida fails to disclose, suggest or discuss operating an electrode that is immersed in a liquid water environment. Thus, Uchida fails to disclose that its water repelling treatment would allow the electrode to operate if the electrode were to be immersed in liquid water. In other words, Uchida fails to disclose that a hydrophilic electrode, such as taught by Grot, could be sufficiently treated with hydrophobic materials such that the electrode would be capable of acting as a gas-diffusion electrode when immersed in liquid water.

Even further, as Applicants have previously presented (see below), Uchida discloses no more than 2 wt% of hydrophilic Nafion<sup>®</sup> in its inventive electrodes. Thus, importantly, Uchida also fails to disclose that its water repelling treatment would allow an electrode having the claimed amount of proton conductor (10-50 wt%) to operate as a gas-diffusion electrode if the electrode were to be immersed in liquid water. Thus, there is no expectation that the “water repellant” teachings of Uchida would successfully keep Grot’s hydrophilic electrode (with its greater amount of hydrophilic Nafion<sup>®</sup>) from flooding in Dempsey’s liquid water environment.

The Examiner also asserts that Vanderborgh discloses hydrophobically treating the electrode to control the wetting of the electrode. In fact, Vanderborgh discloses that certain layers can be treated with hydrophobic materials, such as elemental fluorine, to decrease the wetting tendencies thereof. (See col. 9, lines 7-9 and col. 10, line 66 – col. 11, line 1.) “Decreasing the wetting tendencies” is not a disclosure that the treated electrode is now hydrophobic. Thus, this is not a disclosure that a hydrophilic electrode, such as taught by Grot, could be sufficiently treated with hydrophobic materials such that the electrode would be capable of acting as a gas-diffusion electrode when immersed in liquid water.

Finally, Applicants note that the Examiner has not actually formally presented the combination of references and the rationale that are being relied upon for the presumed obviousness rejection.

- (f) It is appropriate for Applicants to discuss Nafion® with respect to the rejection of Dempsey in view of Grot because Grot discloses that the example inventive electrode ink composition includes Nafion®.**

The Examiner argues in the June 14, 2010 Office Action, paragraph 61, that the claims are not drawn to Nafion® specifically, and thus, a less hydrophilic form or a proton-electron mixed conductive material could be used.

Applicants are arguing against the combination of references cited by the Examiner, in this case the combination of Dempsey in view of Grot. Grot discloses Nafion®. Applicants need only show that it is improper to combine Grot with Dempsey. Thus, Applicants need only show, for example, that an electrode formed from Grot's disclosed electrode ink composition would render Dempsey inoperable. Applicants are not required to include arguments directed to other hypothetical ink compositions.

The Examiner has not yet presented a *prima facie* case that Applicants' claims are rendered unpatentable in view of any reference disclosing a different proton conducting material. Should the Examiner present such a *prima facie* case, Applicants will address that rejection.

- (g) **Cisar fails to disclose, or in any way suggest, that Nafion<sup>®</sup> has hydrophobic characteristics.**

The Examiner argues in the June 14, 2010 Office Action, paragraph 60, that Cisar evidences that Nafion<sup>®</sup> containing electrodes are not inherently plagued by flooding, because the hydrophobic or hydrophilic character of the Nafion<sup>®</sup> is a function of the ratio of the hydrophobic backbone to the hydrophilic sulfonic group concentration. Applicants disagree.

First, Cisar compares Nafion<sup>®</sup> to an experimental Dow product (not Nafion<sup>®</sup> to Nafion<sup>®</sup>) and concludes that a membrane formed of the Dow product gives rise to increased water retention in the membrane which brings about flooding in an electrode impregnated with the Dow product, but not apparently in an electrode impregnated with Nafion<sup>®</sup> (col. 8, line 44 – col. 9, line 3). However, these electrodes are not surrounded by water—rather they are the cathodic electrodes which are surrounded by the reactant gases. Thus, importantly, Cisar never evidences that Nafion<sup>®</sup> containing electrodes are not inherently plagued by flooding when surrounded by water (as disclosed by Dempsey). Even further, Cisar never evidences that Grot's Nafion<sup>®</sup> containing electrodes will not flood when surrounded by water.

Second, Applicants strenuously disagree with the Examiner's assertion that "some Nafion<sup>®</sup> [has] a high degree of hydrophobic character." The Examiner has presented no evidence in support of this assertion. Cisar never evidences nor suggests in any way that Nafion<sup>®</sup>, itself, has a hydrophobic character. Nor does Cisar ever evidence that the hydrophobic or hydrophilic character of Nafion<sup>®</sup> is a function of the ratio of the hydrophobic backbone to the hydrophilic sulfonic group concentration. Further, Vanderborgh's disclosure cited by the Examiner that different ion exchange polymers have different wetting properties is not a disclosure that any of the ion exchange polymers have hydrophobic characteristics.

Should the Examiner maintain his assertion that Nafion<sup>®</sup> may be hydrophobic or that Nafion<sup>®</sup> may have a high degree of hydrophobic character, Applicants respectfully request supporting documentation.

**(h) Dempsey discloses flooding one side of the solid polymer electrolyte membrane with water.**

The Examiner argues in the June 14, 2010 Office Action, paragraph 62, that “although applicant discusses Dempsey’s use of flooding in great detail, one possessing ordinary skill in the art would have recognized that there are other means for self-humidifying a polymer electrolyte that don’t involve the use of flooding.” The Examiner then refers to LaConti to teach that self-humidifying can be accomplished by water vapor.

Applicants have argued, as presented below, that there is a significant difference between humidifying an SPE membrane with liquid water as opposed to water vapor. Dempsey goes to great lengths to form and maintain a hydrated SPE bridge, via flooding with liquid water. Applicants have presented evidence that exposing a solid polymer electrolyte membrane to water vapor is not equivalent to exposing it to liquid water (see Onishi discussing “Schroeder’s paradox”). In short, Onishi teaches that the water uptake of a Nafion<sup>®</sup> membrane exposed only to water vapor could be half that of the water uptake of the membrane exposed to liquid water. In other words, humidifying with water vapor is not equivalent to humidifying with liquid water.

Dempsey also discloses that its hydrated SPE bridge is critical to Dempsey’s operation. Thus, Dempsey teaches away from reducing the functionality of this hydrated SPE bridge.

**(i) Combining Nagata or Tomantscher (US 5,302,274) with Dempsey changes Dempsey’s principle of operation and renders Dempsey unsatisfactory for its intended purpose.**

The Examiner argues in the June 14, 2010 Office Action, paragraphs 66 and 69, that Nagata shows that sensors can be constructed both with and without reference electrodes” and “that one possessing ordinary skill in the art would have recognized that a reference electrode is not necessary for successful gas sensing.” The Examiner also asserts that Applicants’ argument—that “if Dempsey didn’t utilize a reference electrode, then [Dempsey’s] sensor wouldn’t be a potentiostated sensor anymore”—is irrelevant. Applicants disagree.

If one were to eliminate the reference electrode from Dempsey, as the Examiner urges, (1) Dempsey's principle of operation would be changed and (2) Dempsey's gas sensor would be rendered unsatisfactory for its intended purpose. Both of these are impermissible.

As to the first point, it is improper to propose to modify the prior art reference such that the principle of operation of the prior art reference would be changed (MPEP 2143.01(VI)). In this instance, combining Dempsey with Nagata would require a substantial reconstruction and redesign of the elements shown in Dempsey, as well as a change in the basic principle under which Dempsey was designed to operate.

As disclosed in more detail below, Dempsey's basic principle of operation is based on the sensor being a potentiostated sensor such that the sensor's output current may be temperature compensated. Under this principle of operation, the sensing electrode, among other things, is biased to maintain its potential at or above the rest potential of the reference electrode by a fixed amount (col. 2, lines 36-51). The elimination of the reference electrode, as urged by the Examiner in view of Nagata, would completely gut Dempsey's principle of operation.

As to the second point, the proposed elimination of the reference electrode would improperly render Dempsey unsatisfactory for its intended purpose (MPEP 2143.01(V)). Dempsey's gas sensor is intended to be very stable with temperature at zero-air operation (see Title and col. 1, lines 9-12). As discussed in more detail below, if Dempsey was converted from a three-electrode sensor to a two-electrode sensor it would, it would no longer have the means to account for temperature variations during zero-air operations.

The Examiner has failed to provide any reasoned analysis that would support his assertions that it would be obvious to eliminate Dempsey's reference electrode, yet still maintain Dempsey's principle of operation and not render Dempsey unsatisfactory for its intended purpose. Should the Examiner maintain these rejections, Applicants respectfully request that the Examiner provided the missing reasoned explanations.

**V. Res Judicata and the Examination of Claims 1, 2, 9–12, 29–34, 52, 54 and 61–64**

The Examiner takes the position that the rejections of claims 1, 2, 9 – 12, 29 – 34, 52, 54 and 61 – 64 were affirmed by the Board of Appeals in Reexamination 90/006,209, and rejects these claims on the ground of *res judicata*.

**(a) The Patent Office is required to substantively examine claims 1, 2, 9 – 12, 29 – 34, 52, 54 and 61 – 64 for compliance with the patent statute.**

As an initial matter, Applicants assert that a *res judicata* rejection is improper, given the procedural posture of this application. *Res judicata* only pertains when a final judgment on the merits of the case has been entered by a court having jurisdiction over the matter. In this application, prosecution was reopened, and as such, the Board's affirmance of the Examiner's rejection is non-final. (See MPEP 1214.01(I), where it is explicitly stated, when referring to the procedure following new grounds of rejection by the Board, that if the appellant elects to proceed before the Examiner with regard to the new rejection (i.e., if prosecution is reopened, as it was here), the Board's affirmance of the Examiner's rejection will be treated as non-final.) Thus, as no final judgment has been entered in this application, *res judicata* cannot be asserted.

Applicants recognize, with respect to the Reexamination claims (as opposed to claims presented in the Reissue proceeding), that the new ground of rejection raised by the Board reopens prosecution only for the subject matter of the claims to which the new rejection was applied. As the Board applied a new ground of rejection to claims 5, 13 and 57, prosecution of these claims is reopened. As the Examiner has rejected claims 5, 13 and 57 over Dempsey, Uchida, Grot and/or Vanderborgh, and as prosecution of those claims has been reopened, it is entirely proper for Applicants to argue patentability over the asserted combination of references with respect to these claims.

Further, the MPEP also clearly states that “[p]rosecution before the examiner of the 37 CFR 14.50(b) rejection can incidentally result in overcoming the affirmed rejection even though the affirmed rejection is not open to further prosecution.” MPEP 1214.01(I) (emphasis added). Thus, if Applicants' arguments are compelling as to claims 5, 13 and 57, it would be entirely proper for claims 1, 2, 9-12, 29-34, 52, 54 and 61-65 to

be allowed as an incidental result of the continued prosecution of the 37 CFR 14.50(b) rejections.

Even if, *arguendo*, it was proper to apply the doctrine of *res judicata* in the present application, in the Patent Office the doctrine of *res judicata* is to be invoked rarely and only when the same claims (or patentably indistinguishable claims) and the same evidence (regarding the patentability or the unpatentability of the claims) is applied to these claims in the same manner as was previously presented to the Board. In this instance, the evidence is not the same as was previously presented to the Board and at least some of the claims are not the same as were previously presented to the Board.

The Examiner is required to examine the claims and grant patents that comply with the patent statute. This is so, whether or not the application has previously been considered by the Board. The Board has stated, "the policy and purpose of the patent laws preclude the applicability of any doctrine akin to the judicially-developed doctrine of "res judicata" to bar the granting of patents on inventions that comply with the statute," (*Ex parte Conte*, BPAI No. 2000-2033, decided September 20, 2001, citing to *In re Craig*, 411 F.2d 1333, 56 C.C.P.A. 1438 (1969)). The courts have stated, "*res judicata* does not have its usual impact when considering ex parte patent appeals; the public interest in granting valid patents outweighs the public interest underlying collateral estoppel and *res judicata*, particularly where the issue presented is not substantially identical to that previously decided." (*In re Oelrich*, 666 F.2d 578 (Fed. Cir. 1981), fn 2 (citing to *In re Russell*, 58 CCPA 1081, 1083, 439 F.2d 1228, 1230, 169 USPQ 426, 428 (1971); *In re Craig*, 56 CCPA 1438, 1441-42, 411 F.2d 1333, 1335-36, 162 USPQ 157, 159 (1969).) In other words, if the claims being prosecuted comply with the substantive provisions of the patent statute they must be granted.

Additionally, *res judicata* does not automatically apply just because there is an earlier decision by the Board of Appeals. In fact, the MPEP recognizes that the invocation of *res judicata* by the Patent Office has been materially restricted by the courts. (MPEP 706.03(w).) Referring to *In re Craig*, 162 USPQ 157 (CCPA 1969), cited in MPEP 706.03(w), the Court found that the Board of Appeals had improperly sustained



the rejection of the claims under the doctrine of *res judicata* (based on an earlier Board decision for the parent application), even though the Board found the claims to be otherwise patentable. The Court reversed the Board's holding, stating that "claims should not be refused merely because on a previous occasion [i.e., the earlier Board decision] the same or similar claims have been refused on grounds no longer deemed to be valid." *Craig* at 159. In other words, the doctrine of *res judicata* is not binding on the Patent Office.

The *Craig* Court explained that the doctrine of *res judicata*, in the context of patent prosecution, must be balanced against the mandate of the Patent Office to grant patents to inventions that are patentable under the substantive provisions of the patent statute:

"While *res judicata* has its proper place in the law as a reflection of a policy invoked to settle disputes and put an end to litigation, the prosecution of patent applications is not exactly either a dispute or litigation in the usual sense of these terms. There are additional public policy considerations which have a bearing here, namely, furtherance of the policy inherent in the patent laws to grant patents when the Patent Office finds that *patentable* inventions have been disclosed and properly claimed so that such inventions are made public through the grant. The granting of such patents is also in the public interest .... Society stands to lose ... when a patent is refused on an invention which is patentable under the statute." *Craig* at 159.

Further, in *In re Kagan*, 156 USPQ 130 (CCPA 1967), the Court found that the Patent Office was actually estopped from rejecting claims solely on the theory of *res judicata*. "A holding of *res judicata* without reliance on any other ground of rejection is not an examination on the merits of the application and so may not be used [following an adverse Board of Appeals decision]." *In re Craig* at 160, citing to *In re Kagan*. This express admonition is in keeping with the guidance in MPEP 706.03(w), that "when making a rejection on *res judicata*, action should ordinarily be made also on the basis of prior art, especially in continuing applications." In other words, the MPEP directs the Examiner to determine whether the claims are substantively patentable, and if patentable, allowance of those claims should not be refused merely because on a previous occasion the same or similar claims were refused on grounds no longer deemed to be valid.

- (b) **The Patent Office must consider the Applicants' substantive arguments, in their totality, as to the patentability of the claims.**

Even further, application of the doctrine of *res judicata* is especially improper, as in this instance, where a new record (i.e., new or amended claims and/or new evidence) is before the Patent Office. First, in this application Applicants present claims that were not before the Board in the reexamination appeal. Second, Applicants have presented new evidence that was not before the Board in the reexamination appeal (i.e., *see below*, at least Surampudi (US 5,599,638), Onishi (article in The Journal of Physical Chemistry), and the Sigma-Aldrich Material Safety Data Sheet for Nafion 117, if not also Nolan (US 4,171,253) and Neidrach (US 3,435,355), etc.) in support of the patentability of the claims. Third, the Examiner has even presented new evidence that was not before the Board in the reexamination appeal (at least Vanderborgh (US 4,804,592), Nagata (US 4,913,792) and Heilscher (US 5,403,452)) to support his assertions of unpatentability. Thus, as the record now before the Patent Office is not the same record that was before the Board when it issued its earlier decision, the doctrine of *res judicata* does not apply.

The predecessor court to the Federal Circuit has held that claims should be examined when a new record (either amended claims and/or new evidence) presents a new issue from that previously addressed. *See* MPEP 706.03(w); *In re Herr*, 377 F.2d 610, 153 USPQ 548 (CCPA 1967) (claims should have been examined even though claims were identical with claims previously held unpatentable on appeal in the parent application; new evidence submitted); and *In re Russell*, 439 F.2d 1228, 169 USPQ 426 (CCPA 1971) (claims should have been examined even though claims were similar to claims as previously appealed; new Rule 132 affidavits submitted). More recently, in *Ex Parte Gharib* (BPAI No. 2007-0113, October 2007), the Board held that the submission of new evidence, i.e., evidence that was not before the panel in reaching their earlier decision, and the difference in the scope of the claims presented the Board with a different record than in the earlier appeal. According to the Board, this new record required it to consider and weigh anew the totality of the evidence – the doctrine of *res judicata* did not apply. In *Gharib*, the “new evidence” was an article that predated the

filing of the original application. In other words, the “new evidence” was evidence that was newly presented in the prosecution—it was not evidence that was unavailable at the time of the earlier decision.

**(c) The Patent Office cannot summarily rely on findings in an earlier Board decision to thereby refuse to consider Applicants’ substantive arguments.**

In another fairly recent decision, *Ex Parte Rexnord Industries, LLC* (BPAI No. 2007-3920, decided September 2007), the Board held that it was improper for an examiner to invoke *res judicata* without careful consideration of the basis for his reliance on the doctrine of *res judicata*:

“Preclusions, including *res judicata*, are powerful and necessary procedural tools, but they are not magic bullets. Proving a preclusion generally requires careful construction of a supporting case. The present appeal illustrates some of the many ways in which a “*res judicata*” theory can go awry.<sup>8</sup> Since the *res judicata* theory has not been adequately developed in the record before us, we do not give it any weight.”

Footnote 8 of the *Rexnord* Board’s decision states, “There is an implication of serious prosecution misconduct in the *res judicata* argument. ...” Although the link is not explicit, it appears that the Board’s footnote 8 was referring to this statement found in the *Rexnord* Appellant’s Reply Brief, dated January 30, 2007, p. 4:

“Prior to the Examiner’s Answer, the Appellant’s arguments traversing this rejection were ignored on the basis of *res judicata*. As discussed below, the Examiner continues to erroneously rely on *res judicata* as support for the double patenting rejection and dismiss Appellant’s reasoned analysis supporting allowance of claim 3.”

In other words, an examiner cannot summarily and conclusively invoke *res judicata* to thereby refuse to consider Applicants’ substantive analyses as to the patentability of the claims.

Applicants respectfully submit that the new record in the present application presents a new issue that entitles Applicants to the substantive examination of all aspects of the claims. Applicants further respectfully submit that whether or not the Examiner was “affirmed” in the Reexamination Decision (dated March 28, 2007) as to any portion of the Examiner’s arguments (i.e., the combination of Dempsey with any of Uchida,

Vanderborgh or Grot), it is improper for the Examiner to summarily rely on utilizing these references in the same manner, especially given the new record (for example, the evidence presented by the submission of Surampudi, etc.) presented herein by the Applicants with respect to this very combination.

Applicants previously have supplied courtesy copies of *In re Craig, Ex Parte Gharib, Ex Parte Rexnord*, and the above-cited to Reply Brief of *Ex Parte Rexnord* herewith.

**VI. Response to Prior Art Rejections in the Office Action of December 30, 2009**

***i. Claims 1, 5, 9, 11 – 13, 29 – 34, 52, 53, 57, 61, 63 – 65, 67, 71, 73, 75, 77, 78, 82, 86, 88 – 90, 106 – 113, 117, 121, and 123 – 127 are Patentable under 35 USC 103(a)***

Claims 1, 5, 9, 11 – 13, 29 – 34, 52, 53, 57, 61, 63 – 65, 67, 71, 73, 75, 77, 78, 82, 86, 88 – 90, 106 – 113, 117, 121 and 123 – 127 stand rejected as being unpatentable over Dempsey et al. (US 4,277,984) in view of Uchida et al. (US 5,474,857), Grot et al. (US 5,330,860) and/or Vanderborgh et al. (US 4,804,592). This rejection is respectfully traversed as follows.

As an initial matter, given the new record and referring to the above-discussion of *res judicata*, Applicants respectfully assert that the Examiner is required to substantively examine these claims, and further, that it is improper for the Examiner to summarily rely on any finding of the Board as to the teachings of the prior art, either individually or combined, without independently assessing the patentability of the claims.

Second, Applicants have presented compelling arguments (see below) as to why persons of ordinary skill in the art would not and could not successfully combine Uchida, Grot and/or Vanderborgh with Dempsey. In fact, Applicants provide reasoned arguments as to why Dempsey would be rendered inoperable and/or unsatisfactory for its intended purposes. Applicants respectfully request that the Examiner address these substantive arguments.

a. The Cited Prior Art  
Dempsey

Dempsey discloses flooding one side of a solid polymer electrolyte membrane with distilled water. Specifically, a water channel 7, connected to reservoir 1 via hydrated ports 5 and 6, is positioned over an ionically conductive, hydrated SPE bridge 8 formed on the upper surface of membrane 9. (See Fig. 1; col. 4, lines 30-46.) Further, Dempsey expressly discloses that “the surface of the counter electrode and the membrane area around the electrode is flooded.” (Col. 4, lines 46-49.)

Dempsey’s principle of operation relies on flooding one side of the membrane with distilled liquid water. Dempsey discloses that this flooding of the membrane with distilled water provides “self-humidification,” i.e., transport of water in the vapor phase across the membrane. (Col. 7, lines 50-54, referring to Nolan et al. (US 4,171,253) which discloses, at col. 3, lines 22-26, that “this self-humidifying arrangement is possible in SPE-type gas sensor by maintaining the side of the SPE membrane away from the gas side, i.e., away from the side containing the sensing electrode flooded with distilled water.”) Dempsey further discloses that by eliminating the possibility that the membrane will dry out and by providing an ionically conductive, hydrated SPE bridge, the output current from the device is improved. (Col. 3, line 64 to col. 4, line 10.) Thus, Dempsey teaches that flooding one side of the membrane with distilled liquid water is important for its principle of operation.

With respect to the electrodes, Dempsey discloses that the electrodes are each “a bonded mass of particles of a platinum-5% iridium alloy and *hydrophobic* particles such as polytetrafluoroethylene.” (Col. 5, lines 29-33; see also, col. 7, lines 25-31; col. 7, line 65 to col. 8, line 4; col. 8, lines 27-29. Emphasis added.) Dempsey further discloses that “the nature and characteristics of an electrode, comprising a mixture of particles of a gas absorbing noble metal bonded with particles of *hydrophobic* material as well as the process for doing so, are described in detail in U.S. Pat. No. 3,432,355 [“Niedrach”] ....” (Col. 8, lines 31-44. Emphasis added.) Niedrach, in turn, discloses that the electrodes

are purposely made *hydrophobic* to prevent flooding/drowning<sup>1</sup> of the electrode when in contact with water:

The electrodes comprise gas absorbing metal particles bonded together into a cohesive mass with polytetrafluoroethylene and having a coating of polytetrafluoroethylene bonded to the electrode surface in contact with the gas phase. These novel electrode structures, when used in combination with the aqueous electrolyte ... do not require special fabrication or additional precautions to prevent the electrolyte from flooding the surface of the electrode in contact with the gas phase, and thereby "drowning" the electrode which would deleteriously affect the performance of the fuel cell reaction." (Col. 1, lines 19-30.)

Thus, Dempsey discloses (via its citation to Niedrach and its repeated express disclosure that the electrode binder is hydrophobic) that its electrodes are impervious to the water such that flooding/drowning of the electrode does not occur.

In sum, Dempsey teaches the necessity that the counter electrode be surrounded with distilled liquid water in order to keep the membrane and the ionically conducting bridge on the membrane hydrated. Dempsey also teaches the necessity that the electrode be hydrophobic so that drowning of the electrode in the aqueous environment does not occur.<sup>2</sup>

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<sup>1</sup> "Flooding" refers to the penetration of electrolyte into hydrophobic regions of the catalyst layer which should contain only gas. This misplaced liquid hinders and may totally obstruct the supply of reactant gas to local regions of the catalyst. As a result there is an increase in electrode polarization as the non-flooded regions of the electrode are forced to carry more current. The process is self-propagating and will eventually lead to cell failure. In fuel cells having an acid electrolyte the flooding phenomenon is most prevalent at the cathode i.e., at the water-producing electrode. (See WO/1993/003505) High Current Acid Fuel Cell Electrodes.)

See also, EP0046086: "Early in the development of electrodes for fuel cells it was realised that porous, hydrophobic electrodes were desirable especially for use as a hydrogen anode in order to achieve proper control of electrode wetting and to prevent flooding thereof by the electrolyte so that both the reaction gases and the electrolyte had satisfactory access to the electro-catalyst in the electrode."

<sup>2</sup> Further, with respect to the Examiner's assertion on page 7 of the Office Action that Dempsey recognizes that electrodes set forth in the fuel cell prior art would find utility in the sensor of Dempsey (citing to col. 8, lines 30-63, as justification for citing to Uchida,

Uchida, Grot and Vanderborgh

The Examiner has cited to Uchida, Grot and Vanderborgh because each of these references teach, in the context of fuel cells and/or electrolytic cells, the addition of Nafion<sup>®</sup> to an electrode composition.

However, a person of ordinary skill in the art at the time of the invention would have known that the addition of Nafion<sup>®</sup> to an electrode composition would make the electrode non-hydrophobic.

For example, US 5,599,638 to Surampudi et al. (filed October 12, 1993, and thus indicative of the knowledge of a person of ordinary skill in the art at the time of the invention) discloses that two major categories of electrodes exist: gas-diffusion type electrodes and liquid-feed type electrodes (col. 2, lines 35-48). Surampudi discloses that electrodes formed of carbon-supported alloy [catalyst] powder and a Teflon<sup>®</sup> binder yield a gas diffusion electrode (col. 2, lines 25-27). According to Surampudi, gas-diffusion type electrodes, which have poor fuel wetting properties, can be modified for use in liquid feed cells by including substances that improve their wetting properties, *e.g.*, Nafion<sup>®</sup> (col. 4, lines 10-21). Surampudi discloses that the addition of Nafion<sup>®</sup> to an electrode composition allows the liquid surrounding the electrode to flow into or wet the pores, thus creating a liquid-feed type electrode. In other words, Surampudi teaches that electrodes having poor wetting properties (*i.e.*, hydrophobic electrodes) can be converted to electrodes having good wetting properties (*i.e.*, non-hydrophobic electrodes) by the addition of Nafion<sup>®</sup>.

Nafion<sup>®</sup> is a co-polymer of tetrafluoroethylene and perfluorovinylether sulfonic acid. Nafion<sup>®</sup> has a hydrophobic backbone (Teflon) with sulfonic acid (SO<sub>3</sub>H) side groups. The sulfonic acid side groups are hydrophilic (*see* 2007: Onishi L. et al., "Water-

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Vanderborgh or Grot), Applicants submit that this recognition by Dempsey of fuel cell prior art electrodes is limited to *hydrophobic* electrodes, such as those taught by Niedrach.

Nafion Equilibria. Absence of Schroeder's Paradox," The Journal of Physical Chemistry, B 2007; 111(34):10166-73 (copy previously supplied) [[http://ecsmmeet6.peerexpress.org/ms\\_files/ecsmmeet6/2007/05/21/00001757/00/1757\\_0\\_art\\_0\\_jieoej.pdf](http://ecsmmeet6.peerexpress.org/ms_files/ecsmmeet6/2007/05/21/00001757/00/1757_0_art_0_jieoej.pdf)]). Applicants also refer to the Sigma-Aldrich "Material Safety Data Sheet for Nafion® 117," copy previously supplied. At page 3, this data sheet discloses that Nafion® is hygroscopic, i.e. capable of easily absorbing moisture. Thus, it is clear that, in at least some aspects, the hydrophilic nature of Nafion's sulfonic acid side groups impart hydrophilic or hygroscopic properties to Nafion® as a whole. And, in fact, Surampudi refers to Nafion® as a "hydrophilic proton-conducting polymer (see col. 12, lines 60-63).

Importantly however, Surampudi goes beyond merely teaching that Nafion® has hydrophilic side groups and hydrophilic properties. Surampudi teaches that gas-diffusion type electrodes, which have poor fuel wetting properties, can be modified for use in liquid feed cells by including substances that improve their wetting properties, *e.g.*, Nafion® (col. 4, lines 10-21). Surampudi discloses that the addition of Nafion® to an electrode allows the liquid surrounding the electrode to flow into or wet the pores, thus creating a liquid-feed type electrode. In other words, Surampudi teaches that electrodes having poor wetting properties (*i.e.*, hydrophobic electrodes) can be converted to electrodes having good wetting properties (*i.e.*, non-hydrophobic electrodes) by the addition of Nafion®. It is in this context that Applicants referred to Nafion® as a "non-hydrophobic binder," i.e., when added to an electrode, Nafion® allows water to flow into and flood the pores of the electrode. A flooded electrode cannot be used as a gas-diffusion type electrode—in other words, a flooded electrode cannot be used to react with (or sense) gases.

Thus, Uchida, Grot and Vanderborgh, by disclosing the addition of Nafion® to the electrode compositions, all disclose liquid-fuel type electrodes, *i.e.*, electrodes that will allow water to penetrate their pores.<sup>3</sup>

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<sup>3</sup> A liquid-fuel type electrode can be used in a non-liquid environment and operated as a gas-diffusion electrode. However, if a liquid-fuel type electrode is used in a liquid



Uchida

Contrary to the Examiner's repeated assertions, Uchida fails to disclose electrodes having the claimed composition, i.e., a proton-electron mixed conductive material having 10-50 wt % of a proton conductor material and 50-90 wt % of a first and a second electrical conductor material.

Example 1 of Uchida discloses that 1g of Nafion<sup>®</sup> polymer was added to 60g of n-butyl acetate to form a colloidal dispersion. Then 50g of Pt-C (having 10-25% platinum catalyst) were added to this colloidal dispersion. The resulting paste was coated on carbon paper. Thus, the disclosed electrode of example 1 has 2.0 wt% proton conductor material (1g Nafion<sup>®</sup> / (1g Nafion<sup>®</sup> + 50g Pt-C)) and 98 wt% electrical conductor material (50g Pt-C / (1g Nafion<sup>®</sup> + 50g Pt-C)).

Examples 2-6 maintain the same solids ratios, merely swapping out the organic solvents.

Example 7 adds an additional 25g of carbon powder (having 25-70 wt% PTFE) to the colloidal dispersion. Thus, the disclosed electrode of example 7 has 1.3 wt% proton conductor material (1g Nafion<sup>®</sup> / (1g Nafion<sup>®</sup> + 50g Pt-C + 25g C/PTFE)) and 75.7 wt% to 90.4 wt% electrical conductor material ((50g Pt-C + 30% to 75% of (25g C/PTFE)) / (1g Nafion<sup>®</sup> + 50g Pt-C + 25g C/PTFE)).

Thus, while the claims require 10-50 wt % of a proton conductor material, none of the inventive examples of Uchida have a wt % of Nafion<sup>®</sup> that exceeds 2.0 wt %.

Uchida's comparative example is disclosed at col. 7, line 54 to col. 8, line 7. Uchida's comparative example does not explicitly disclose the amounts of the Pt-C component (10-25 wt% platinum) or of the C/PTFE component (25-70 wt% PTFE). Uchida discloses that the Pt-C and the C/PTFE are sprinkled on carbon paper and hot pressed to form an electrode. This hot pressed Pt-C with C/PTFE layer does not include a proton conductor material.

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environment, it cannot then operate as a gas-diffusion electrode, as its pores will be flooded.

At the top of col. 8, in a new paragraph, Uchida discloses that a *coat* of Nafion<sup>®</sup> is applied to the previously hot-pressed catalyst layer of the electrode. In other words, in the comparative example, Uchida discloses that the Nafion<sup>®</sup> coat is a separate layer formed on the electrode after the electrode has been hot pressed. This separate Nafion<sup>®</sup> coating does not include any electrical conductor material.

Thus, with respect to the comparative example, Uchida fails to disclose any material having a proton-electron mixed conductive material. Rather, Uchida discloses two material layers: the hot pressed Pt-C with C/PTFE layer (and with no proton conductor material) and the Nafion<sup>®</sup> layer (with no electrical conductor material). These two distinct layers do not form a single proton-electron mixed conductive material as required by the claims of the instant application.

And, in fact, this is exactly the point of Uchida's comparative example—to compare the separate Nafion<sup>®</sup> and carbon layers of the comparative example to Uchida's inventive examples, which have a low level of Nafion<sup>®</sup> mixed in with the electrical conductor material. Given this, it is irrelevant what weight percent this separate Nafion<sup>®</sup> proton conductive layer has relative to the Pt-C with C/PTFE electron conductive layer.

Thus, neither Uchida's inventive examples (Examples 1-7) nor Uchida's comparative example disclose a proton-electron mixed conductive material having 10-50 wt % of a proton conductor material.

#### Vanderborgh

Vanderborgh fails to disclose electrodes having the claimed composition, i.e., an electrical conducting material that is a proton-electron mixed conductive material having 10-50 wt % of a proton conductor material and 50-90 wt % of a first and a second electrical conductor material.

Vanderborgh discloses that an object of the invention is to provide a composite electrode which is constructed to have increasing electronic conductivity from the catalyst loading zone to a current collector on one face of the electrode, and to have

increasing protonic conductivity from the zone of the catalyst loading to the face of the electrode which engages the ion exchange membrane. (Col. 3, lines 37-44).

Vanderborgh accomplishes this by providing an electrode comprised of three zones or layers. Referring to FIG. 2, Vanderborgh discloses that the composite electrode is formed of three separate layers (22, 24 and 26), each layer prepared by combining its constituents dispersed in a suitable dispersant and spraying the individual layer's formulation on either a membrane or a current collector (col. 8, lines 13-20 and lines 49-56). Subsequently, the individual layers are thermally bonded to each other (col. 8, lines 13-15; col. 8, lines 59-62). Each layer comprises a mixture of carbon black, platinum, PTFE and a suitable ionic conducting material (col. 8, lines 16-20).

Table I discloses the compositional parameters for each layer. Layer 22 has a proton conducting material weight percent of 4.3% (.021/.491) and an electrical conducting material weight percent of 82.3% (.304/.491). Layer 24 has a proton conducting material weight percent of 4.4% (.119/2.718) and an electrical conducting material weight percent of 91.2% (2.48/2.718). Layer 26 has a proton conducting material weight percent of 74% (.422/.570) and an electrical conducting material weight percent of 12.1% (.069/.570). None of these layers has 10-50 wt % of a proton conductor material and 50-90 wt % of a first and a second electrical conductor material, as required by the claims.

Further, it would be improper to consider the entire composite electrode of Vanderborgh as a single electrical conducting material, i.e., to consider the three separate layers 22, 24, 26 to be a single material. Each separate layer of the electrode is a distinct material—bonding the layers together does not form a new “material.”

#### Grot

In the example referred to by the Examiner, Grot discloses using a non-hydrophobic binder (Nafion<sup>®</sup>) for its fuel cell electrode (col. 14, lines 15-27). In addition to the teachings of Surampudi, discussed above, (i.e., that the addition of Nafion<sup>®</sup> to an electrode composition creates a non-hydrophobic, liquid-fuel type electrode), Grot

expressly discloses that the electrode is a “gas-**liquid** permeable porous electrode.” (Col. 1, lines 31-32; emphasis added.) Thus, Grot explicitly discloses that its electrode is a liquid-fuel type electrode, i.e., an electrode that is specifically designed to allow the penetration of the liquid into the pores of the electrode.

Grot further explicitly discloses that its membrane and electrode structure is useful in electrolytic cells where, for example, the anode electrolyzes an aqueous solution. Thus, again Grot discloses that the electrode is a liquid-fuel type electrode (col. 13, lines 35-50).

b. The Proposed Combination of References Changes Dempsey’s Principle of Operation and, in fact, Renders Dempsey Unsatisfactory for its Intended Purpose

The Examiner has indicated that it would have been obvious to utilize the teachings of Uchida, Grot and/or Vanderborgh for the sensor of Dempsey. Applicants disagree.

If one were to replace the hydrophobic electrodes, as expressly taught by Dempsey, with non-hydrophobic electrodes as taught by Grot (or Uchida, or Vanderborgh), Dempsey’s principle of operation would be changed. In fact, Dempsey would be rendered inoperable or, at the very least, unsatisfactory for its intended purpose due to flooding of the electrodes of Grot (or Uchida, or Vanderborgh).

Dempsey teaches a gas sensor that uses a gas permeable (i.e. a gas-diffusion type) electrode. However, Dempsey also teaches surrounding the area of the counter electrode with distilled liquid water. Dempsey then further explicitly and repeatedly teaches using a hydrophobic binder for the electrodes. (Col. 8, lines 34-44.) Niedrach (cited by Dempsey to disclose the electrodes used in the gas sensor of Dempsey and the process of making these electrodes) explicitly teaches using hydrophobic electrodes so that the electrodes will not “drown” in an aqueous environment (Neidrich, col. 1, lines 19-30). In essence, Dempsey teaches away from using a non-hydrophobic binder for the electrodes.

Uchida discloses including a non-hydrophobic binder (Nafion<sup>®</sup>) in its fuel cell electrodes.

Vanderborgh discloses including a non-hydrophobic binder (Nafion<sup>®</sup>) in its fuel cell electrodes.

Grot discloses including a non-hydrophobic binder (Nafion<sup>®</sup>) in its fuel cell electrodes.

Surampudi teaches that the inclusion of Nafion<sup>®</sup> in the electrode composition converts a gas-diffusion type electrode into a liquid-fuel type electrode.

A person of ordinary skill in the art would realize that replacing Dempsey's gas-diffusion type, hydrophobic electrodes with a liquid-fuel type electrode as taught by Grot (or Uchida, or Vanderborgh) would result in the electrodes being flooded/drowned with the distilled water, such that the gas to be reacted would be unable to reach the reaction sites within the electrodes. (See discussion of Surampudi, above.) In essence, Dempsey's gas sensor would be unable to sense or react to the gas. Thus, contrary to the Examiner's assertion, as the combination renders Dempsey's sensor inoperable, one of ordinary skill in the art would have reason to NOT replace the hydrophobic electrodes of Dempsey with the non-hydrophobic electrodes of Grot (or Uchida, or Vanderborgh).

c. The Proposed Combination of References Fails to Disclose Each and Every Element of the Claimed Invention

Dempsey discloses surrounding the counter electrode with *liquid water*. However, the claims require "means, containing a volume of *water vapor*, for exposing a surface of said counter electrode to said water vapor." Dempsey fails to disclose that the counter electrode is exposed to water vapor.

It appears that the Examiner is simply equating Dempsey's disclosure of liquid water as a disclosure of water vapor. However, in the context of solid polymer electrolyte membranes, it has long been known in the art that these membranes respond dramatically differently when exposed to liquid water as opposed to water vapor. This different response is referred to as "Schroeder's paradox."<sup>4</sup> Basically, the water-uptake

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<sup>4</sup> "In polymer electrolyte membranes such as Nafion<sup>®</sup> the increasing uptake of water strongly depends on the equilibration with water vapor or liquid water. Usually, with

of a polymer electrolyte membrane, such as Nafion<sup>®</sup>, exposed to liquid water is significantly greater than the water-uptake of the same membrane exposed to 100% relative humidity water vapor. For example, the water-uptake is approximately 30 wt % with liquid water at room temperature and 15 wt % at 100% relative humidity.<sup>5</sup>

As discussed above, Dempsey explicitly discloses that the counter electrode side of the solid polymer electrolyte membrane is “flooded with distilled water,” particularly in the area where the Dempsey’s membrane was specially treated with boiling water to create “a swollen, hydrated, ionically conductive SPC bridge.” Dempsey teaches that the flooding of one side of the membrane with distilled water is important for its principle of operation.

Schroeder’s paradox teaches that water vapor is not equivalent to liquid water in the context of hydration of Nafion<sup>®</sup> membranes. Thus, a person of ordinary skill in the art would recognize that replacing the liquid water of Dempsey with water vapor would, among other things, reduce the hydration of the swollen membrane bridge that Dempsey went to special lengths to achieve and would degrade the current output of Dempsey’s sensor. Even further, Onishi (see footnote 4) teaches that “[m]embrane water content dramatically affects membrane transport properties, such as proton conductivity and water diffusion coefficient.”

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increasing relative humidity, water-uptake also increases. If such a membrane is brought into contact with liquid water, instead of water vapor saturated gas, the water-uptake increases dramatically (e.g., water-uptake is approximately 15 wt. % at 100% RH and 30 wt. % with liquid water at room temperature). This is generally known as Schroeder’s paradox.” US Published Patent Application No. 2007/0178341, “Gas channel coating with water-uptake related volume change for influencing gas velocity,” to Wieser, published August 2, 2007. *See also*, 2007: Onishi L. et al., “Water-Nafion Equilibria. Absence of Schroeder’s Paradox,” *The Journal of Physical Chemistry, B* 2007;111(34):10166-73 (“Numerous water uptake studies have been conducted,<sup>3-11</sup> and Schroeder’s paradox has been reported in Nafion.<sup>3-5, 8, 10, 12-16</sup>”) [Hereinafter “Onishi”; summary found at [http://ecsmmeet6.pccrpress.org/ms\\_files/ecsmmeet6/2007/05/21/00001757/00/1757\\_0\\_art\\_0\\_jieoej.pdf](http://ecsmmeet6.pccrpress.org/ms_files/ecsmmeet6/2007/05/21/00001757/00/1757_0_art_0_jieoej.pdf), copy previously supplied.]

<sup>5</sup> *Id.*

The claims require that the surface of the counter electrode is exposed to water vapor. Dempsey fails to disclose that the counter electrode is exposed to water vapor. Grot (or Uchida, or Vanderborgh) fail to cure this deficiency. Thus, each and every element is not disclosed by the cited combination of references.

Further, the Examiner has failed to provide any rationale as to why one of ordinary skill in the art would consider Dempsey's disclosure of liquid water as a disclosure of water vapor. Nor has the Examiner provided any rationale as to why one would replace the liquid water of Dempsey with water vapor. And indeed, Applicants submit that replacing the liquid water of Dempsey with water vapor would render Dempsey unsatisfactory for its intended purpose. Thus, Applicants respectfully submit that the Examiner has failed to provide a clear articulation of why the cited references would have rendered the claimed invention obvious as required by *KSR Int'l Co. v. Teleflex Inc.*, 82 USPQ2d 1385, 1395-97 (2007) and MPEP 2143.

**iii. Claims 2, 54, 79 and 114 are Patentable under 35 USC 103(a)**

Claims 2, 54, 79 and 114 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dempsey in view of Grot, Uchida and/or Vanderborgh as applied to claims 1, 52, 78 and 112 above, and further in view of La Conti et al. (US 4,820,386). The rejection is respectfully traversed for the reasons discussed below.

Applicants present herein compelling arguments (see below) as to why persons of ordinary skill in the art would not combine LaConti with Dempsey. Applicants respectfully request that the Examiner address these substantive arguments.

Claims 2, 54, 79 and 114 each recite that the water vapor containing means contains a volume of water and an antifreeze additive.

As an initial matter, LaConti fails to cure the deficiencies of Uchida, Grot and Vanderborgh discussed above.

Further, as also discussed above, Dempsey expressly teaches the importance of having one side of its solid polymer electrolyte membrane flooded with distilled water.

In particular, Dempsey teaches that an ionically conductive, hydrated bridge between the sensing and reference electrodes enhances the current output (col. 3, line 64 to col. 4, line 10). Dempsey discloses that this hydrated bridge is formed using a special technique (exposing the bridge area to boiling water, three times) and that this specially swollen, hydrated bridge is flooded with distilled water.

LaConti discloses a sensor cell having a proton-conducting membrane with sensing and counter electrodes located on the same side of the membrane. Fig. 1 discloses that the membrane is hydrated with a water reservoir on the side of the membrane opposite to the sensing and counter electrodes. LaConti then further discloses that the membrane can be hydrated using water vapor instead of liquid water so long as the relative humidity in the vicinity of the cell membrane is maintained above 80%. (Col. 11, lines 34-41.) LaConti discloses that a water vapor transport film, allowing only the passage of pure water vapor, may be inserted between the cell membrane and the water source, thereby allowing for the use of impure water (e.g., water with glycol). (Col. 11, lines 42-53.)

LaConti, in contrast to Dempsey, fails to disclose that a swollen, ionically conductive, hydrated SPE bridge is formed on the surface of the electrolyte membrane. Thus, LaConti's disclosure that water vapor at or above 80% relative humidity may be used in LaConti's invention in place of liquid water is not a disclosure that water vapor may be used in place of liquid water in Dempsey's invention. In fact, Schroeder's paradox, as discussed above, teaches that the water uptake of the solid polymer electrolyte membrane from water vapor would be significantly less than the water uptake from liquid water. A person of ordinary skill in the art would not equate exposing Dempsey's swollen, ionically conductive, hydrated SPE bridge to liquid water with exposing Dempsey's hydrated SPE bridge to water vapor.

Even further, providing a water vapor transport film between the reservoir and the solid polymer electrolyte membrane, as disclosed in LaConti, would defeat Dempsey's disclosure that the electrolyte membrane be flooded with liquid water.



Thus, Applicants respectfully submit that claims 2, 54, 79 and 114 are patentable over the cited references.

*iv. Claims 3, 55, 80 and 115 are Patentable under 35 USC 103(a)*

Claims 3, 55, 80 and 115 are rejected under 35 USC 103(a) as being unpatentable over Dempsey in view of Grot, Uchida and/or Vanderborgh as applied to claims 1, 52, 78 and 112 above, and further in view of Hielscher et al. (US 5,403,452). The rejection is respectfully traversed for the reasons discussed below.

As an initial matter, Hielscher fails to cure the deficiencies of Dempsey, Uchida, Grot and Vanderborgh discussed above.

Claims 3, 55, 80 and 115 each recite, among other things, that the surface of the sensing electrode that is exposed to the ambient atmosphere has a surface area smaller than the surface area of the surface of the counter electrode that is exposed to said water vapor.

Hielscher discloses a sensor for determining the gas concentrations in a mixture of gases. The sensor has a solid electrolyte provided with measuring, counter and reference electrodes.

The principle of operation of Hielscher's sensor is almost diametrically opposed to the principle of operation of Dempsey's sensors. For example, Hielscher explicitly teaches against the use of "watery electrolytes or polymeric solid electrolytes" (referring to Dempsey, col. 1, lines 11-31). Further, in contrast to Dempsey, Hielscher expressly discloses that its solid electrolyte cannot transfer or accept the gas component to be detected. (Col. 3, lines 41-42 and col. 4, lines 57-59.) Even further, in contrast to Dempsey, Hielscher discloses that the electrodes are inert to the gas (col. 3, lines 42-46; col. 7, lines 36-38). Hielscher also discloses, in contrast to Dempsey, that the ions of the solid electrolyte combine with the different gas components (col. 6, lines 11-15), thereby forming salts at the electrolyte/electrode/gas boundary. Hielscher further discloses that contrary to the electrolyte that has a solubility for the electrochemical reaction product, in

the case of a solid cat-ionic electrolyte, the reaction product [i.e., the salt] has to be electrochemically decomposed. (Col. 4, lines 6-9.)

Hielscher is particularly concerned with the prevention of the formation of a permanent layer of metal salt on the measuring electrode. (Col. 4, lines 13-43 and lines 46-51.) Thus, Hielscher teaches limiting the formation of the salts in the first place and electrochemically decomposing any such salts that do form on the measuring electrode. To electrochemically decompose any salts that do form, Hielscher discloses limiting the current density at the surface of the measuring electrode where the layer of salt is formed to below a certain amount. (Col. 4, lines 39-43 and col. 5, lines 18-23.) It is within this context, that Hielscher discloses that the electrochemically effective current density at the counter electrode should be smaller than that at the measuring electrode. (Col. 8, lines 29-44.) In contrast, Dempsey has no such concerns.

The Examiner asserts that “it was known to make the counter electrode larger than the sensing electrode so that the counter electrode does not diffusion-limit the sensor response.” This is irrelevant. First, the claims do not require that the counter electrode be larger than the sensing electrode. Rather, the claims require that the surface of the sensing electrode that is exposed to the ambient atmosphere has a surface area smaller than the surface area of the surface of the counter electrode that is exposed to said water vapor. The claims are directed to the relative sizes of exposed surface areas not to the relative sizes of the electrodes. Second, neither Dempsey nor Hielscher are concerned with whether or not the counter electrode diffusion-limits the response. For example, Dempsey not only fails to discuss “diffusion limiting,” but also teaches that the sensing and counter electrodes have the same diameter (col. 11, lines 65-67). Hielscher is concerned with decomposing salts that form at the measuring electrode. As such, there is no valid rationale for applying Hielscher’s disclosure regarding the relative sizes of the counter or measuring electrode to the gas sensor of Dempsey.

Given the vast disparity in the principles of operation between Dempsey and Hielscher, a person of ordinary skill in the art would have no reason to apply the

teachings of Hielscher, as to the formation or regeneration of salts, to the gas sensor of Dempsey.

Even further, neither Dempsey nor Hielscher disclose the surface of the counter electrode is exposed to water vapor. Dempsey discloses that the counter electrode is surrounded by liquid water. Hielscher discloses that the counter electrode is not exposed to water vapor or liquid water—in fact, Hielscher teaches against the use of water in any form. In other words, neither Dempsey nor Hielscher disclose than any surface area of the surface of the counter electrode is exposed to water vapor, much less that such surface area is greater than a surface area of the sensor electrode. Thus, even if one were to combine the references, each and every element of the claims would not be present.

v. *Claims 4, 56, 81 and 116 are Patentable under 35 USC 103(a)*

Claims 4, 56, 81 and 116 are rejected under 35 USC 103(a) as being unpatentable over Dempsey and Hielscher in view of Grot, Uchida and/or Vanderborgh as applied to claims 3, 55, 80 and 115 above, and further in view of La Conti. This rejection is respectfully traversed for the reasons discussed below.

Claims 4, 56, 81 and 116 each recite, among other things, that the surface area of the surface of the counter electrode that is exposed to said water vapor is separated from said means for exposing a surface of said counter electrode to said water vapor by a hydrophobic membrane permeable to water vapor and substantially impervious to water.

As discussed above with respect to the rejections of claims 2, 54, 79 and 114, LaConti fails to cure the deficiencies of Dempsey, Uchida, Grot and Vanderborgh. Specifically, among other things, Applicants have shown that combining Uchida, Grot and/or Vanderborgh and LaConti with Dempsey would render Dempsey inoperable or, at the very least, unsatisfactory for its intended purpose.

Further, as discussed above, with respect to claims 3, 55, 80 and 115, it is improper to combine the disclosure of Hielscher with Dempsey as the principles of operation of the Hielscher and Dempsey sensors are completely disparate.

*vi. Claims 10, 62, 66, 70, 72, 74, 76, 87, 122 and 128 – 132 (and claims 6 and 73 in the alternative) are Patentable under 35 USC 103(a)*

Claims 10, 62, 66, 70, 72, 74, 76, 87, 122 and 128 – 132 (and claims 67 and 73 in the alternative) are rejected under 35 USC 103(a) as being unpatentable over Dempsey in view of Grot, Uchida and/or Vanderborgh as applied to claims 1, 52, 78 and 112 above, and further in view of Tomantschger et al. (US 5,302,274). This rejection is respectfully traversed for the reasons discussed below.

As an initial matter, claims 10, 62, 66, 70, 72, 74, 76, 87, 122 and 128 – 132, and claims 67 and 73, all recite or depend from claims that recite “wherein the electrical conducting material of at least one of said sensing and counter electrodes is a proton-electron mixed conductive material having 10-50 wt % of a proton conductor material and 50-90 wt % of a first and a second electrical conductor material.” Tomantschger fails to cure the deficiencies of Dempsey combined with Uchida, Grot and/or Vanderborgh, as discussed above with respect to this recitation. Thus, for at least the reasons discussed above, these claims are patentable.

Further, claims 66, 70, 72, 74 and 76 each recite that the sensing and counter electrodes are the only two electrodes in contact with the electrolyte membrane.

The Examiner has indicated that Tomantschger teaches that it is unnecessary to have three electrodes for the gas sensor as only two are necessary for sensor operation. Applicants submit that Tomantschger's teachings are not relevant to or combinable with Dempsey's teachings. Even further, Applicants submit that Dempsey teaches that three electrodes are necessary for its principle of operation.

Dempsey's principle of operation would be completely changed should it be converted from a three-electrode sensor to a two-electrode sensor, i.e., should its third electrode (the reference electrode) be eliminated. The entire focus of Dempsey's disclosure is the interaction of the reference electrode with the sensing electrode such that Dempsey's potentiostated, three-electrode sensor will have highly invariant background current characteristics with temperature during zero-air operation (see Title). Without a

reference electrode, Dempsey could no longer be a potentiostated sensor. The Examiner recognizes this, but argues that the “whole reason the current variations were present in the first place in Dempsey was a function of its arrangement of sensor, counter, and reference electrodes and how these electrodes were interfaced with each other to an external voltage source.” In essence, it appears that the Examiner is also arguing that the proposed modification of Dempsey from a three-electrode sensor to a two-electrode sensor would completely change Dempsey’s principle of operation. Applicants assert that it is improper to combine references if doing so would completely change the principle of operation, and so, for this reason alone, it is improper to combine Nagata’s teachings with Dempsey.

Further, the Examiner has indicated that obviating the need for a potentiostated sensor simplifies the circuitry and is therefore an advantage. While this may or may not be true (note that the contemporaneously filed application, S/N 773,136 to LaConti (aka, “Nolan”) referred to in Dempsey indicated that the potentiostated, three-electrode sensor solved certain problems associated with non-potentiostated, two-electrode sensors), the point is that *Dempsey’s entire principle of operation is based on the sensor being a potentiostated sensor having a reference electrode*. For example, Dempsey teaches that, although the cell output current may be temperature compensated to cancel errors due to changes in temperature (see Fig. 3 and col. 9, lines 37-62), Dempsey’s use of the reference electrode eliminated the need for temperature compensation under “zero-air” conditions. This use of the reference electrode is a key feature of Dempsey’s principle of operation. As another example, should Dempsey no longer have a reference electrode, it would no longer have a use for a swollen, hydrated, ionically conductive bridge between the sensing and reference electrode. Yet, this bridge is a key feature of Dempsey’s principle of operation. In short, Dempsey without a reference electrode is no longer Dempsey.

Applicants respectfully submit that Tomantschger’s disclosure as to a two-electrode sensor is not relevant to Dempsey’s sensor, and in particular, is not germane to Dempsey’s disclosure concerning its reference electrode. Specifically, *Dempsey uses its*

*reference electrode to account for temperature variations during zero-air operations.* Tomantschger fails to disclose that its two-electrode configuration can account for temperature variations during zero-air operations. Thus, it is improper to apply Tomantschger's teaching of a sensor without a reference electrode to Dempsey's disclosure of a temperature invariant sensor. At the very least, Tomantschger's disclosure that two-electrode sensors may be commensurate with three-electrode sensors under certain operating conditions and functional requirements, is not applicable to Dempsey where the functional requirements differ from Tomantschger's. Indeed, if one were to eliminate the reference sensor from Dempsey, as disclosed by Tomantschger, Dempsey's sensor would no longer be operative for its disclosed purpose—i.e., stable zero-air operation under changing temperature conditions.

Specifically, Dempsey discloses that a reference electrode 11 is provided on the same surface as the sensing electrode to eliminate large background current variations with *temperature variations* during zero-air operations. (*See*, Title; col. 1, lines 24-37; col. 2, lines 6-13; col. 4, lines 11-29; col. 4, line 67 – col. 5, line 5; and col. 6, lines 10-12 and lines 30-37.) The reference electrode is positioned as close as possible to the sensing electrode, while being maintained remote from the flux lines between the sensing and counter electrodes, *so that the reference and sensing electrodes may be subjected to the same temperature conditions.* (Col. 4, lines 11-29 and col. 6, lines 10-12.) Further, Dempsey discloses using a potentiostatic circuit to maintain the potential of the sensing electrode at a desired level and to maintain a fixed potential difference between the sensing electrode and the reference electrode to permit invariant and accurate operation with time and *with changes in temperature.* (Col. 4, line 67 – col. 5, line 5.)

In contrast, Tomantschger appears to simply assume that, in the absence of the contaminant gas, a specific or known electrical potential (which could be zero) will be developed between the sensor electrode 12 and the counter electrode 16. (Col. 11, lines 12-26.) Thus, with respect to the two-electrode configuration, Tomantschger fails to recognize that temperature variations may cause the electrical potential between the

sensor and counter electrodes to change. Tomantschger fails to even recognize the problem that Dempsey's reference electrode is meant to solve.

Further, in contrast to Dempsey, in the three-electrode configuration Tomantschger fails to disclose the use of the reference electrode to maintain the potential of the sensor electrode to account for changes in temperature. Rather, Tomantschger (referring to FIG. 6) discloses a potentiometric measurement means is provided between the reference electrode and the sensor electrode. In other words, Tomantschger *measures* the potential between the reference and sensor electrodes—Tomantschger does not *maintain* the potential of the sensor electrode. Thus, as Tomantschger apparently uses a reference electrode for a different purpose than Dempsey uses a reference electrode, Tomantschger's disclosure that the reference electrode need not be used under certain conditions is inapposite to Dempsey's disclosure.

As to the Examiner's contention that Dempsey's reference electrode is the source of the temperature variation problem, Applicants disagree and maintain their arguments as presented above and in the previously filed responses. Further, Applicants submit that there is no disclosure in Dempsey that the reference electrode is the source of the "background current" that Dempsey want to eliminate—rather, it appears that the effect of temperature variation on the sensing electrode relative to the counter electrode causes the undesirable background current. Even further, it is irrelevant if, *arguendo*, Dempsey's reference electrode is the source of the problem. All that matters is that the reference electrode of Dempsey cannot be eliminated without disrupting or completely changing the principle of operation of Dempsey.

As the Examiner has recognized that Dempsey fails to disclose that the sensing electrode and the counter electrode are the only two electrodes, and as Tomantschger, as discussed above, fails to disclose that the reference electrode of Dempsey could be eliminated without disrupting the principle of operation of Dempsey, the combination of Dempsey in view of Tomantschger fails to render claims 10, 62, 66, 70, 72, 74, 76, 87, 122 and 128 – 132 unpatentable. Further, as none of Uchida, Grot and/or Vanderborgh

discloses two-electrode sensors, Uchida, Grot and/or Vanderborgh fail to cure the deficiency of Dempsey in view of Tomantschger.

Claims 72, 76 and 128 - 132

Claims 72, 76 and 128 – 132 additionally recite, or depend from a claim reciting, that the sensing electrode reacts with the gas to produce a change in electrical characteristic between the sensing electrode and the counter electrode “*in the absence of an applied voltage to the sensing electrode.*” Dempsey particularly discloses that the sensing electrode is maintained at a potential (col. 2, lines 40-62). Tomantschger, referring to the two-electrode embodiment of FIG. 7, expressly discloses that a specific voltage is developed and maintained between the sensor electrode and the counter electrode (col. 11, lines 3-6). Thus, the combination of Dempsey in view of Tomantschger and Uchida, Grot and/or Vanderborgh fails to disclose the “absence of an applied voltage to the sensing electrode.”

Claims 67 and 73

Claims 67 and 73 were rejected in the alternative. Claim 67 includes the recitation of “the sensing electrode reacting with the gas to produce a change in an electrical characteristic between the sensing electrode and the counter electrode in the absence of an applied voltage to the sensing electrode.” Claim 73 recites “in the absence of any biasing voltage.”

Dempsey expressly teaches that “the voltage [of the sensing electrode] should not be allowed to fall below approximately 1.0 volts in order to maintain an oxide coating on the surface of the catalytic sensing electrode to prevent CO poisoning of the electrode and to prevent reduction of oxygen at the electrode or other competing reactions which introduce error currents.” (Col. 10, lines 3-9.) In other words, *Dempsey expressly teaches that its sensor electrode would be poisoned by CO in the absence of a maintained voltage of 1.0 or greater.* Tomantschger fails to disclose that its sensor would not be subjected to CO poisoning.



In fact, Tomantschger, referring to the two-electrode embodiment of FIG. 7, expressly discloses that a specific voltage is developed and maintained between the sensor electrode and the counter electrode (col. 11, lines 3-6).

In light of this express teaching and in the absence of any teaching as to why the electrodes of Uchida, Grot and/or Vanderborgh would not be poisoned by CO, Applicants submit that a person of ordinary skill in the art would not have combined the cited references such as to render claims 67 and 73 unpatentable.

For all the above reasons, the subject claims are patentable over the applied citations.

***vii. Claims 66, 70, 72, 74, 76 and 12 – 132 are Patentable under 35 USC 103(a)***

Claims 66, 70, 72, 74, 76 and 128 – 132 are rejected under 35 USC 103(a) as being unpatentable over Dempsey in view of Grot, Uchida and/or Vanderborgh as applied to claims 1, 52, 78 and 112 above, and further in view of Nagata et al. (US 4,913,792). This rejection is respectfully traversed for the reasons discussed below.

As an initial matter, as discussed above, Dempsey teaches away from using an electrode as taught by Grot (or Uchida, or Vanderborgh). Further, there is no reasonable expectation of success for the combination of Grot, Uchida and/or Vanderborgh with Dempsey. And, in fact, Applicants have shown above that combining Grot, Uchida and/or Vanderborgh with Dempsey would render Dempsey inoperable. Nagata fails to cure these deficiencies.

Nagata discloses three-electrode gas sensors. Nagata further discloses that for certain configurations of three-electrode sensors, operating under certain conditions and accompanied by specific modifications to the electrodes, the reference electrode of a three-electrode sensor can be eliminated. The Examiner relies upon the disclosure of Nagata to argue that Dempsey's sensor could be constructed without the presence of a reference electrode provided that one is willing to utilize a suitably large counter electrode (OA, p. 18). Applicants disagree and submit that the Examiner is improperly applying the teachings of Nagata to Dempsey.

Dempsey's principle of operation would be completely changed should it be converted from a three-electrode sensor to a two-electrode sensor, i.e., should its third electrode (the reference electrode) be eliminated. The entire focus of Dempsey's disclosure is the interaction of the reference electrode with the sensing electrode such that Dempsey's potentiostated, three-electrode sensor will have highly invariant background current characteristics with temperature during zero-air operation (see Title). Without a reference electrode, Dempsey could no longer be a potentiostated sensor. The Examiner recognizes this, but argues that the "whole reason the current variations were present in the first place in Dempsey was a function of its arrangement of sensor, counter, and reference electrodes and how these electrodes were interfaced with each other to an external voltage source." In essence, it appears that the Examiner is also arguing that the proposed modification of Dempsey to a two-electrode sensor would completely change its principle of operation. Applicants assert that it is improper to combine references if doing so would completely change the principle of operation, and so, for this reason alone, it is improper to combine Nagata's teachings with Dempsey.

Further, the Examiner has indicated that obviating the need for a potentiostated sensor simplifies the circuitry and is therefore an advantage. While this may or may not be true (note that the contemporaneously filed application, S/N 773,136 to LaConti (aka, "Nolan") referred to in Dempsey indicated that the potentiostated, three-electrode sensor solved certain problems associated with non-potentiostated, two-electrode sensors), the point is that *Dempsey's entire principle of operation is based on the sensor being a potentiostated sensor having a reference electrode*. For example, Dempsey teaches that, although the cell output current may be temperature compensated to cancel errors due to changes in temperature (see Fig. 3 and col. 9, lines 37-62), Dempsey's use of the reference electrode eliminated the need for temperature compensation under "zero-air" conditions. This use of the reference electrode is a key feature of Dempsey's principle of operation. As another example, should Dempsey no longer have a reference electrode, it would no longer have a use for a swollen, hydrated, ionically conductive bridge between the sensing and reference electrode. Yet, this bridge is a key feature of Dempsey's principle of operation. In short, Dempsey without a reference electrode is no longer

Dempsey, i.e., its entire principle of operation would be gutted and it would be rendered unsatisfactory for its intended purpose.

Even further, the three-electrode sensor of Dempsey differs significantly from the three-electrode sensor of Nagata, and thus, one would not consider applying the teachings of Nagata's three-electrode sensor to the three-electrode sensor of Dempsey. Because of the significant differences between the three-electrode sensor of Dempsey and the three-electrode sensor of Nagata, Nagata's teaching that two-electrode sensors may be utilized in place of three-electrode sensors is not applicable to the sensors of Dempsey. Some of the significant differences between the three-electrode sensors of Dempsey and Nagata include:

- Dempsey's sensing electrode is maintained at a fixed potential above the reference electrode to produce rapid oxidation of the gaseous constituent to be detected and above the rest potential of the electrode in the uncontaminated atmosphere (col. 2, lines 40-48); Nagata's working electrode is maintained at a set potential from the counter electrode (col. 3, lines 13-27).
- Dempsey's thermal, chemical and electrical characteristics for its sensing and reference electrodes are as similar as possible (col. 4, lines 11-21); Nagata's working electrode is a Pt electrode and its reference electrode is an Ag electrode (col. 5, lines 11-17).
- Dempsey's reference electrode is exposed to the uncontaminated atmosphere, i.e., to the atmosphere without the gaseous constituent being measured; Nagata's reference electrode is exposed to the same constituents as the working and counter electrodes.
- Dempsey's sensing electrode is the only electrode exposed to the gas constituent being measured (see Fig. 1); Nagata's working, counter and reference electrodes are all exposed to the gas constituent being measure (see Figs. 1 and 2, gas-permeable film 5).
- Dempsey discloses a hydrated gas sensor for operation from 1°C to 40°C; Nagata discloses a flammable gas sensor for operation from 100°C to 400°C.

Thus, it can be seen that Dempsey's reference electrode performs a completely different function than that of Nagata's reference electrode. Dempsey's reference electrode, which is as similar as possible to the sensing electrode and positioned as close as possible to the sensing electrode, and which is exposed to the atmosphere without the contaminating gas, is used, at least in part, to provide temperature stability during "zero-air" operation. In contrast, Nagata's reference electrode, which is not similar to the working electrode and which is exposed to the same contaminated atmosphere as the working electrode, is not used to provide temperature stability during "zero-air" operation. As the three-electrode sensor of Nagata so significantly differs in its construction and operation from the three-electrode sensor of Dempsey, there is no predictability or reasonable expectation of success that Nagata's teachings concerning three- and two-electrode sensors could be applied to Dempsey's three-electrode sensor.

As to the Examiner's contention that Dempsey's reference electrode is the source of the temperature variation problem, Applicants disagree and maintain their arguments as presented above and in the previously filed responses. Further, Applicants submit that there is no disclosure in Dempsey that the reference electrode is the source of the "background current" that Dempsey want to eliminate—rather, it appears that the effect of temperature variation on the sensing electrode relative to the counter electrode causes the undesirable background current.

As the Examiner has recognized that Dempsey fails to disclose that the sensing electrode and the counter electrode are the only two electrodes, and as Nagata, as discussed above, fails to disclose that the reference electrode of Dempsey could be eliminated without disrupting the principle of operation of Dempsey, the combination of Dempsey in view of Nagata fails to render claims 66, 70, 72, 74, 76 and 128 – 132 unpatentable. Further, as none of Uchida, Grot and/or Vanderborgh discloses two-electrode sensors, Uchida, Grot and/or Vanderborgh fail to cure the deficiency of Dempsey in view of Nagata.

Claims 72, 76 and 128 - 132

Claims 72, 76 and 128 – 132 additionally recite, or depend from a claim reciting, that the sensing electrode reacts with the gas to produce a change in electrical characteristic between the sensing electrode and the counter electrode “*in the absence of an applied voltage to the sensing electrode.*” Dempsey particularly discloses that the sensing electrode is maintained at a potential (col. 2, lines 40-62). Nagata also discloses that the working electrode has an applied voltage (see item 9 in Fig. 8 and col. 7, line 66 – col. 8, line 5). Thus, the combination of Dempsey in view of Nagata and Uchida, Grot and/or Vanderborgh fails to disclose the “absence of an applied voltage to the sensing electrode.”

Claim 130

Claim 130 additionally recites that the sensing and the counter electrodes have a diameter of about 15 mm. Nagata discloses that the two-electrode sensor is only feasible if the “counter electrode is larger in area than the working electrode by a factor of a two-figure number or more ....” In other words, Nagata expressly teaches away from the interchangeability of three-electrodes and two-electrodes when the electrode areas are of the same order of magnitude. Thus, the combination of Dempsey in view of Nagata and Uchida, Grot and/or Vanderborgh fails to disclose each and every element of claim 130.

For all the above reasons, the subject claims are patentable over the applied citations.

**VII. New Claim 133**

New claim 133 additionally recites that the surface of the sensing electrode that is exposed to the ambient atmosphere has a surface area that is smaller than the surface area of the surface of the counter electrode that is exposed to the water vapor, whereby a positive pressure of the water vapor exists from the surface of the counter electrode exposed to the water vapor to the surface of the sensing electrode exposed to the ambient atmosphere. This recitation is similar to the recitation of claim 3.

Thus, Applicants respectfully submit that new claim 133 is patentable at least for the reasons that claim 3, as discussed above, is patentable.

**VIII. Conclusion**

Applicants respectfully request reconsideration of the claims in light of the entirety of the evidence presented herein.

Respectfully submitted,  
Shen et al.

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